



EXPLORE FLIGHT

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Communications challenges in the Extensible Traffic Management domain

Dr. Jaewoo Jung, AAAI 2022 Spring Symposium, Stanford University



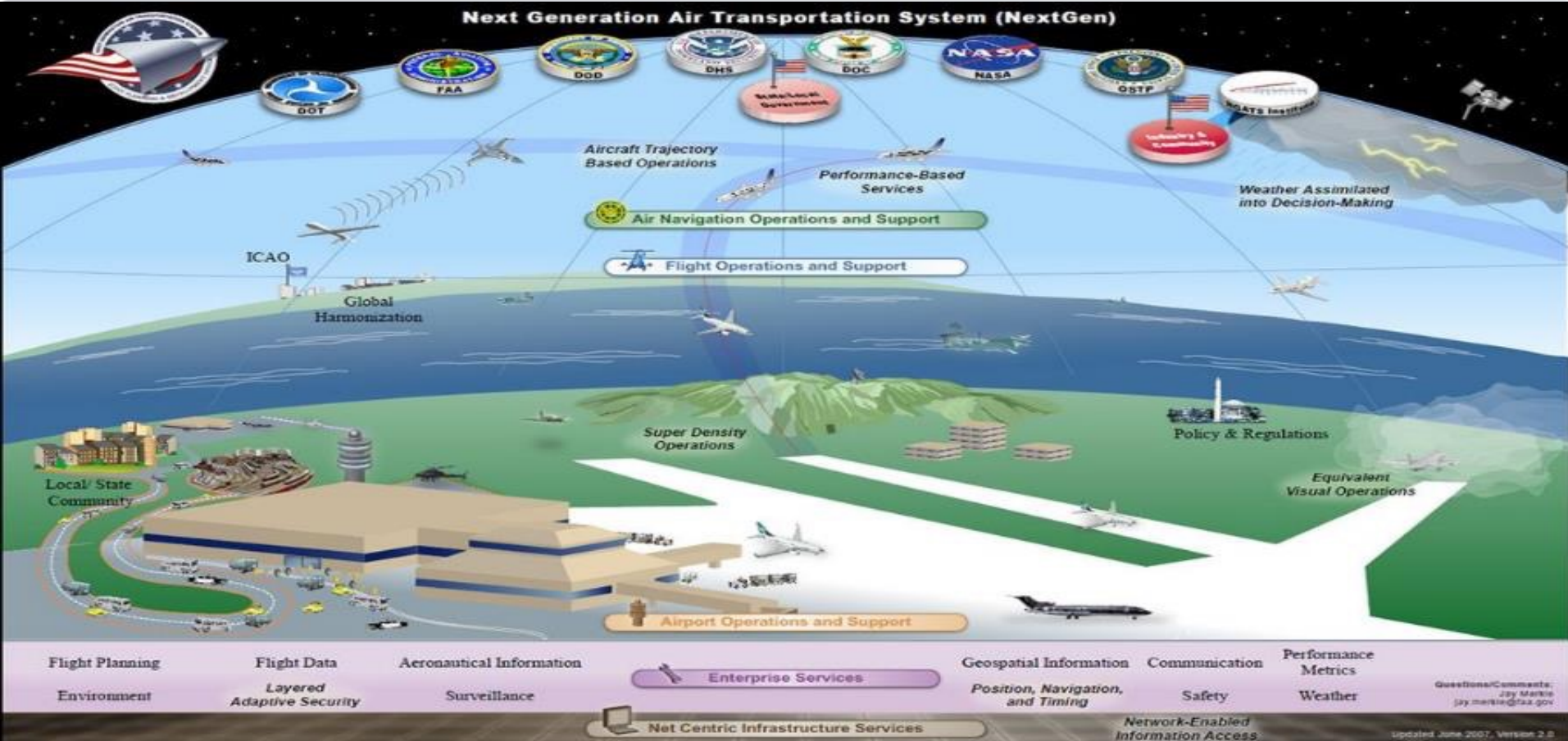
Outline



- What is Extensible Traffic Management (xTM)?
- xTM example: Unmanned Aircraft Systems (UAS) Traffic Management, UTM
- xTM example: upper Class E Traffic Management (ETM)
- Role of communications in the xTM and associated challenges



Vision of the future, from the past





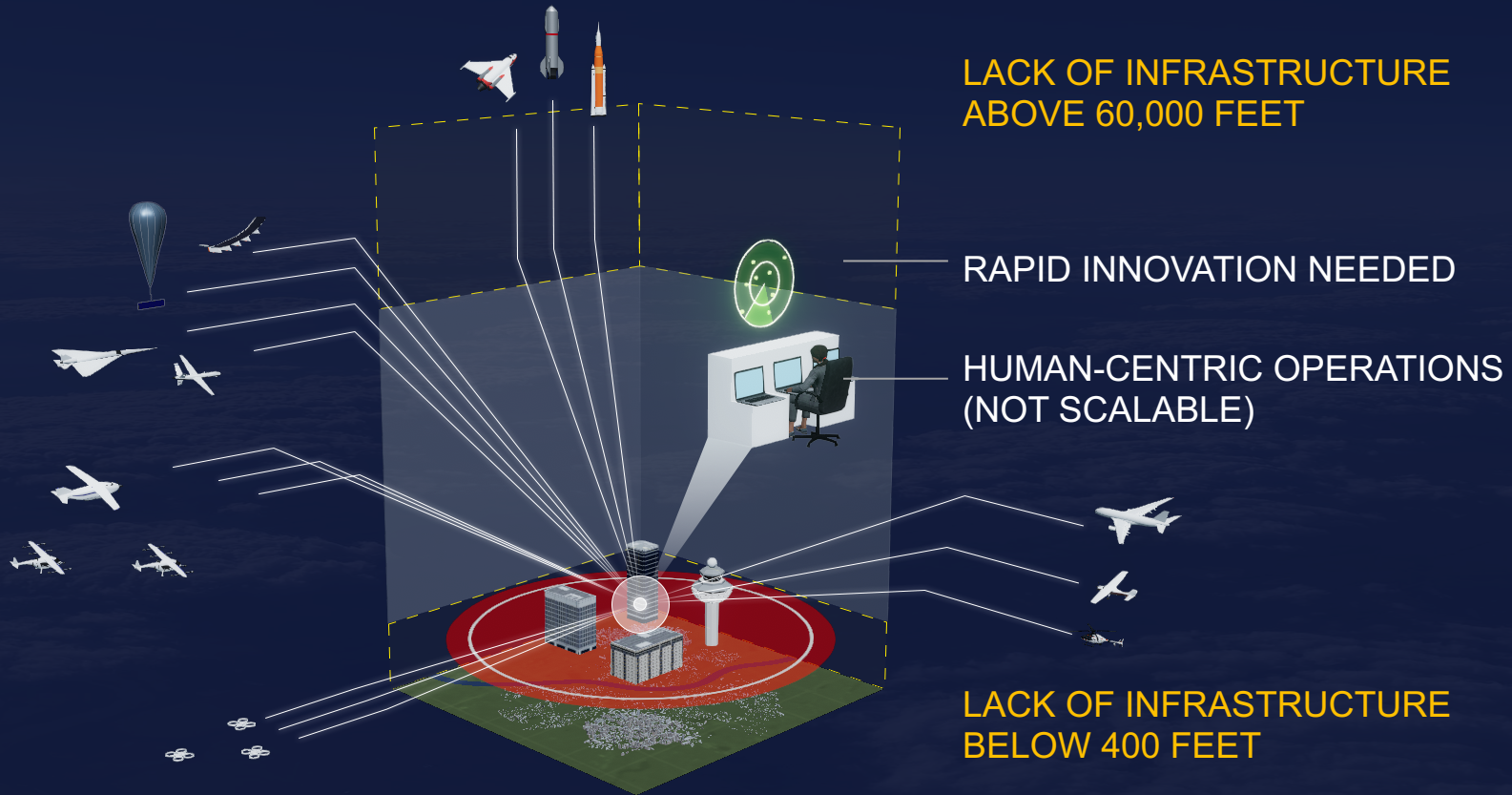
Vision of the future, 20 years later



nari.arc.nasa.gov/skyforall/



More diverse operations coming. Are we ready?





Extensible Traffic Management (xTM): Automated traffic management systems for highly automated operations

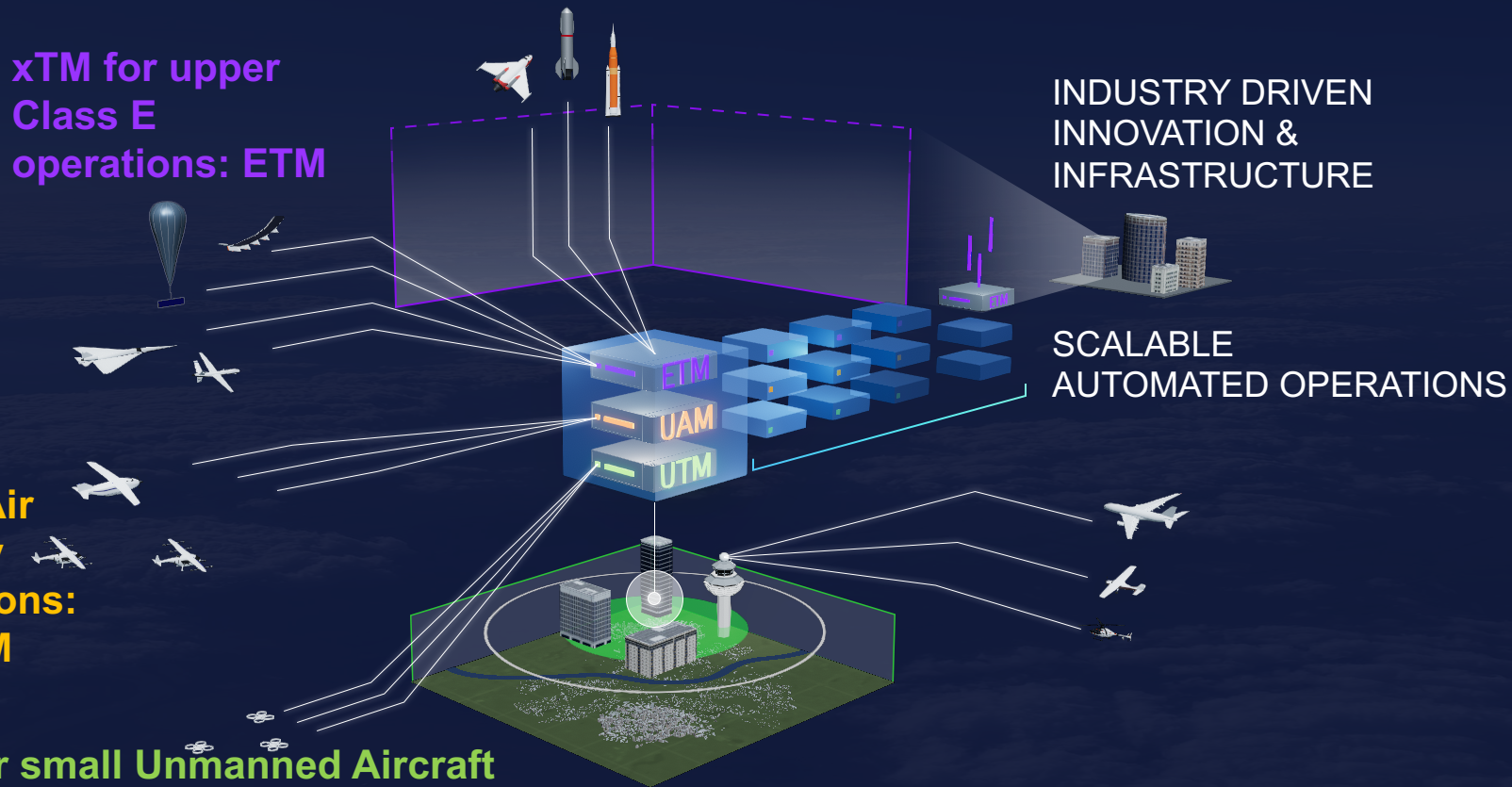
xTM for upper
Class E
operations: ETM

xTM for
Urban Air
Mobility
Operations:
UAM TM

xTM for small Unmanned Aircraft
Systems (UAS) Operations: UTM

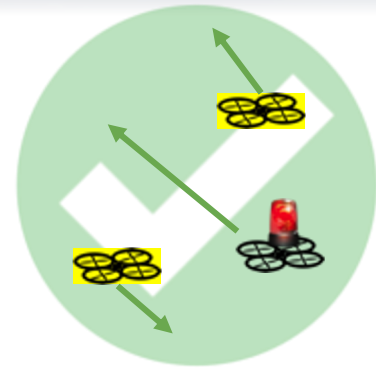
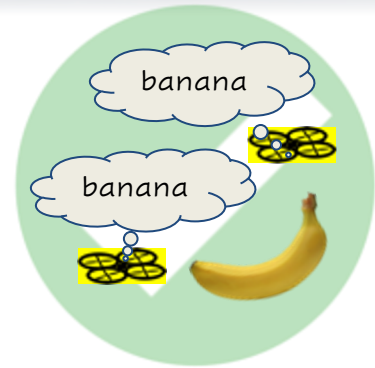
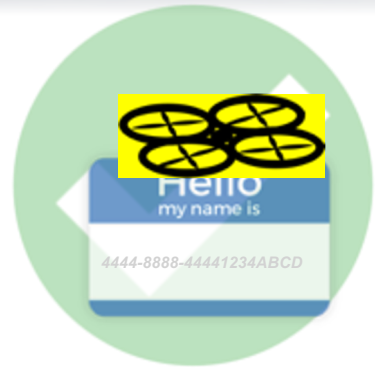
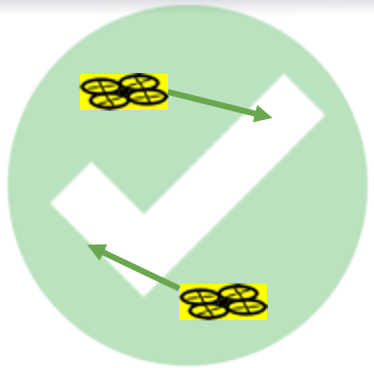
INDUSTRY DRIVEN
INNOVATION &
INFRASTRUCTURE

SCALABLE
AUTOMATED OPERATIONS





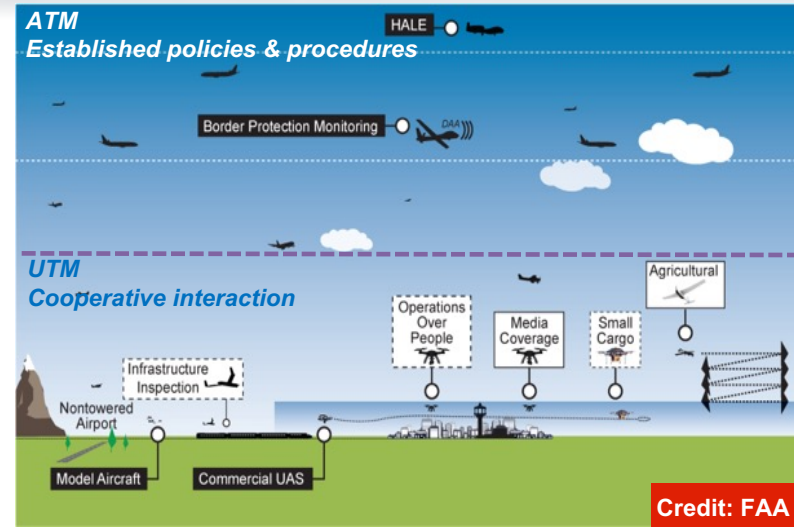
Extensible Traffic Management (xTM) Core Principles





Let's look at xTM system example, Unmanned Aircraft Systems (UAS) Traffic Management (UTM)

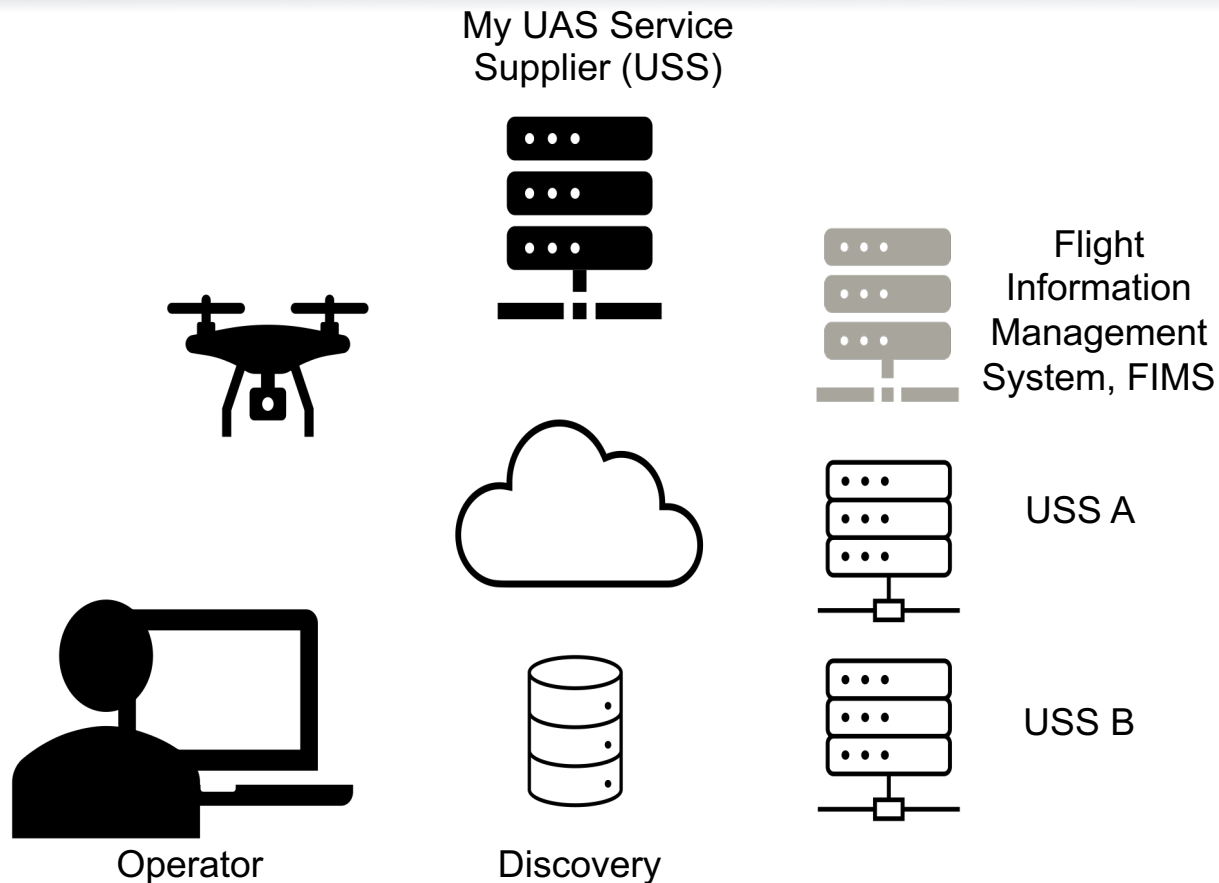
- UTM is an “air traffic management” ecosystem for uncontrolled airspace
- UTM utilizes industry's ability to supply services under FAA's regulatory authority where these services do not exist
- UTM development will ultimately enable the management of large scale, low-altitude UAS operations



- Operational concept will address beyond visual line of sight UAS operations under 400 ft. AGL, Class G airspace
- Roles/responsibilities of FAA and operators
- Information architecture, data exchange protocols, software functions
- System performance requirements

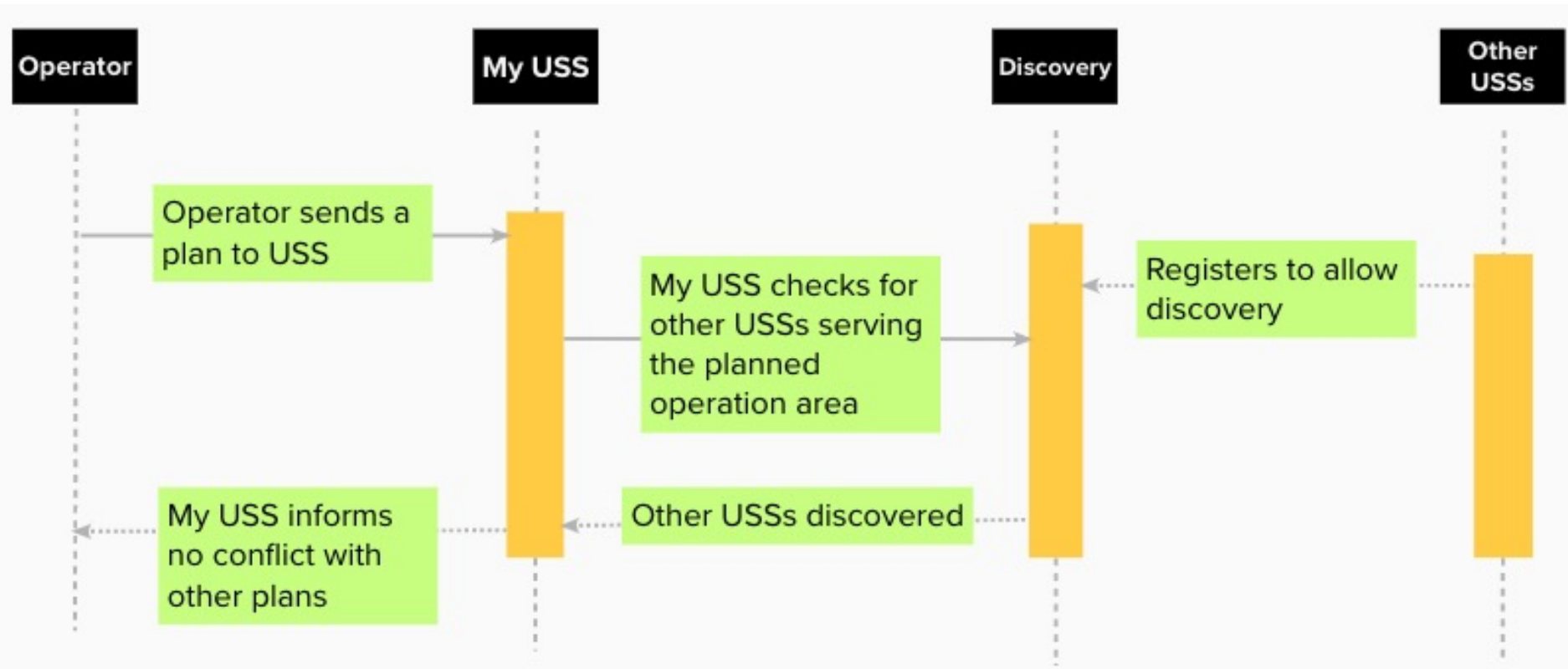


Simplified UTM Architecture



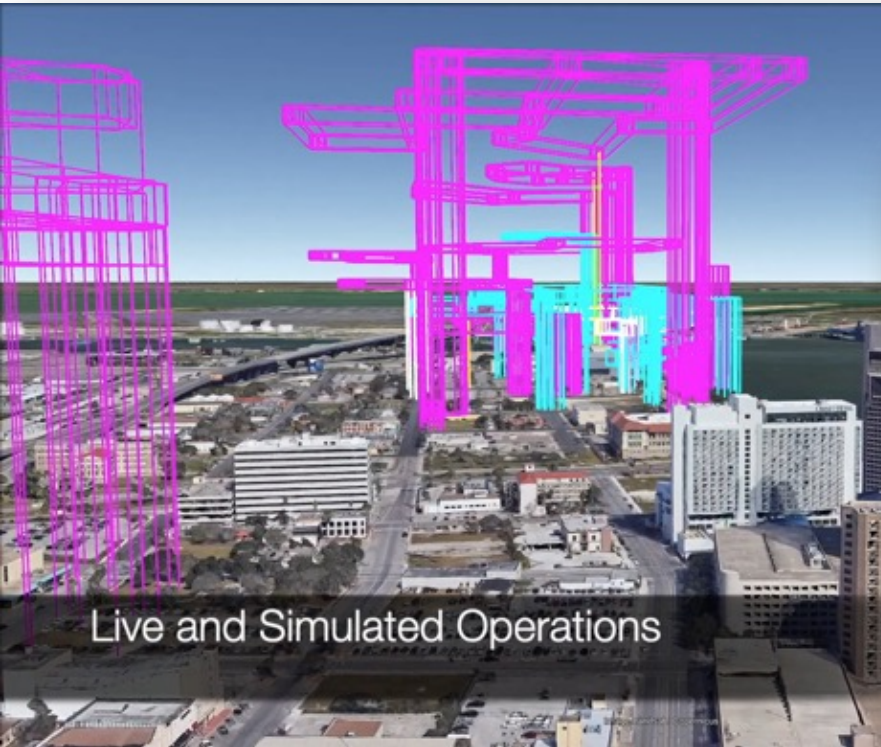


Operation Planning in UTM

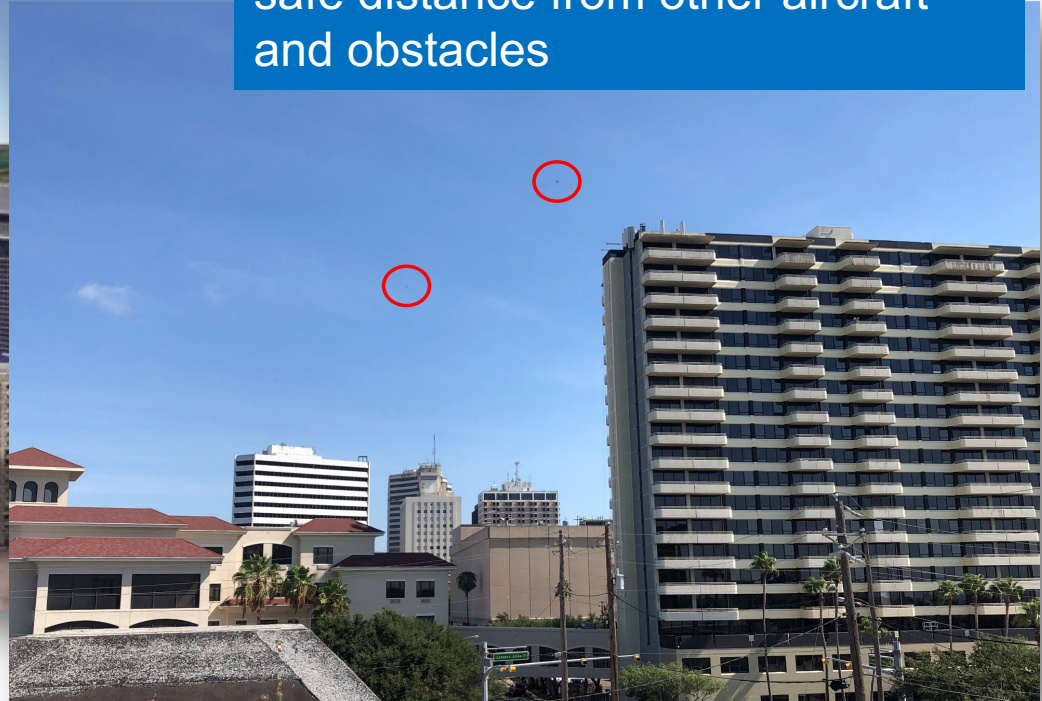




Operation Execution in UTM



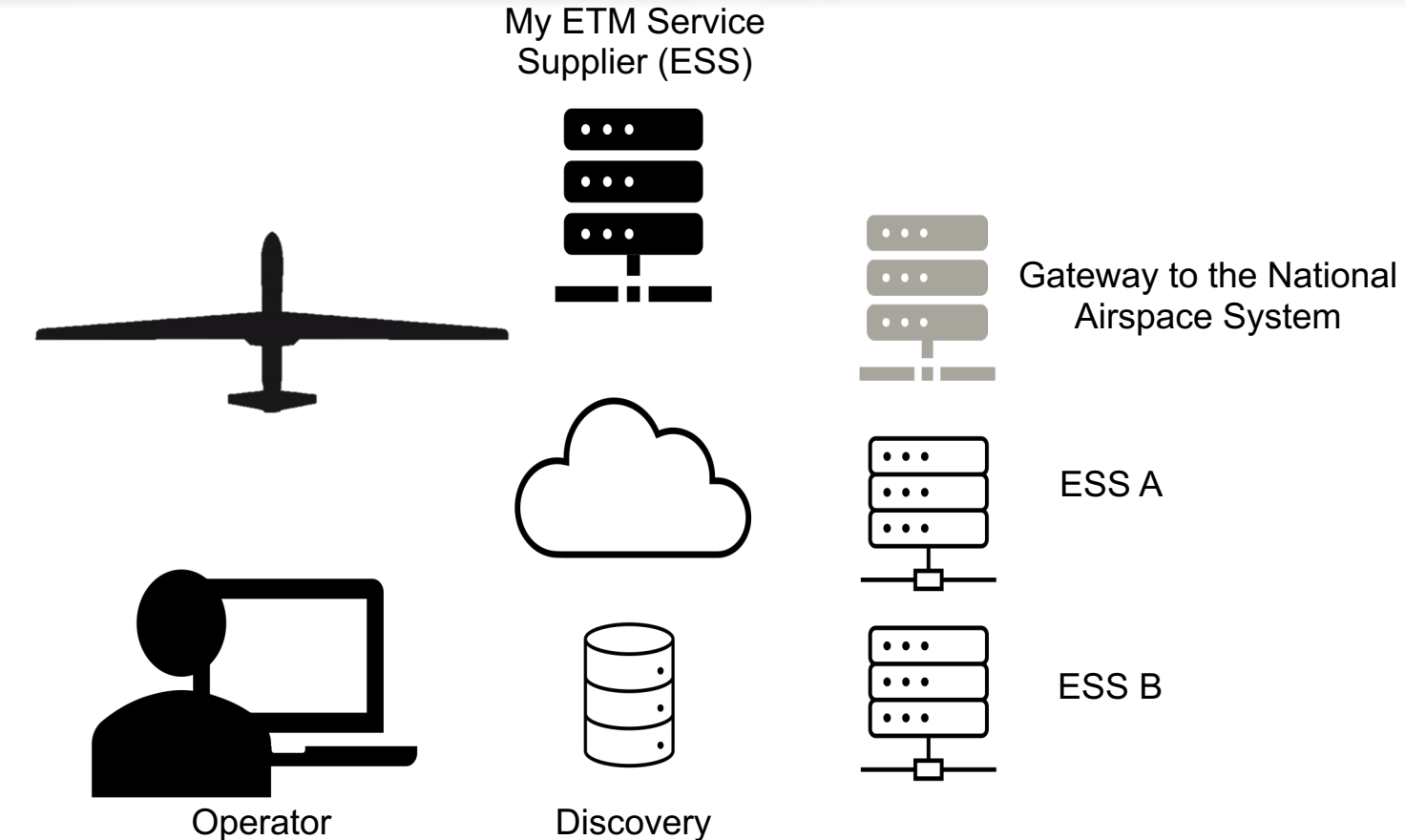
UA are to stay within planned operational intent area to maintain safe distance from other aircraft and obstacles



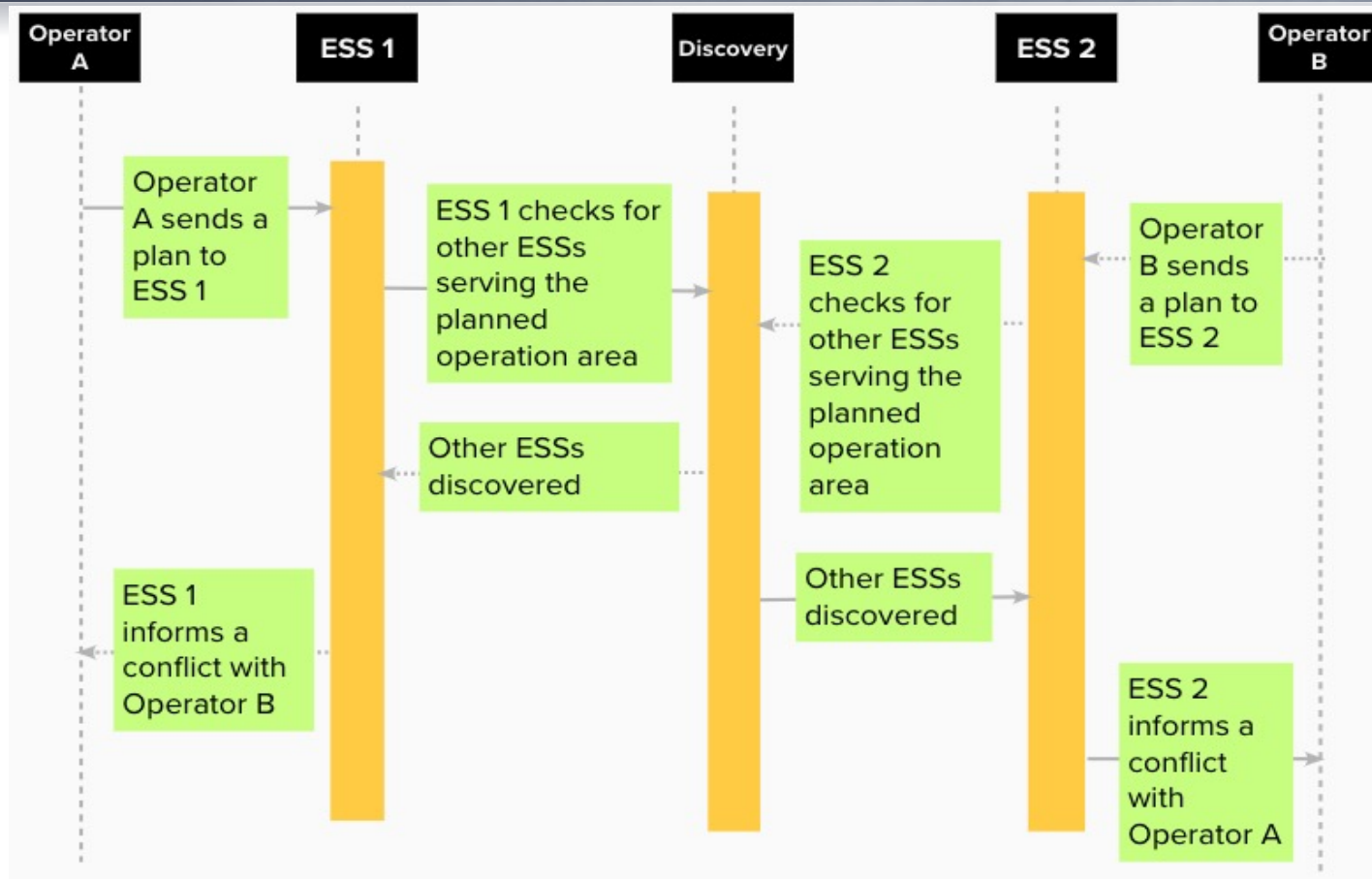
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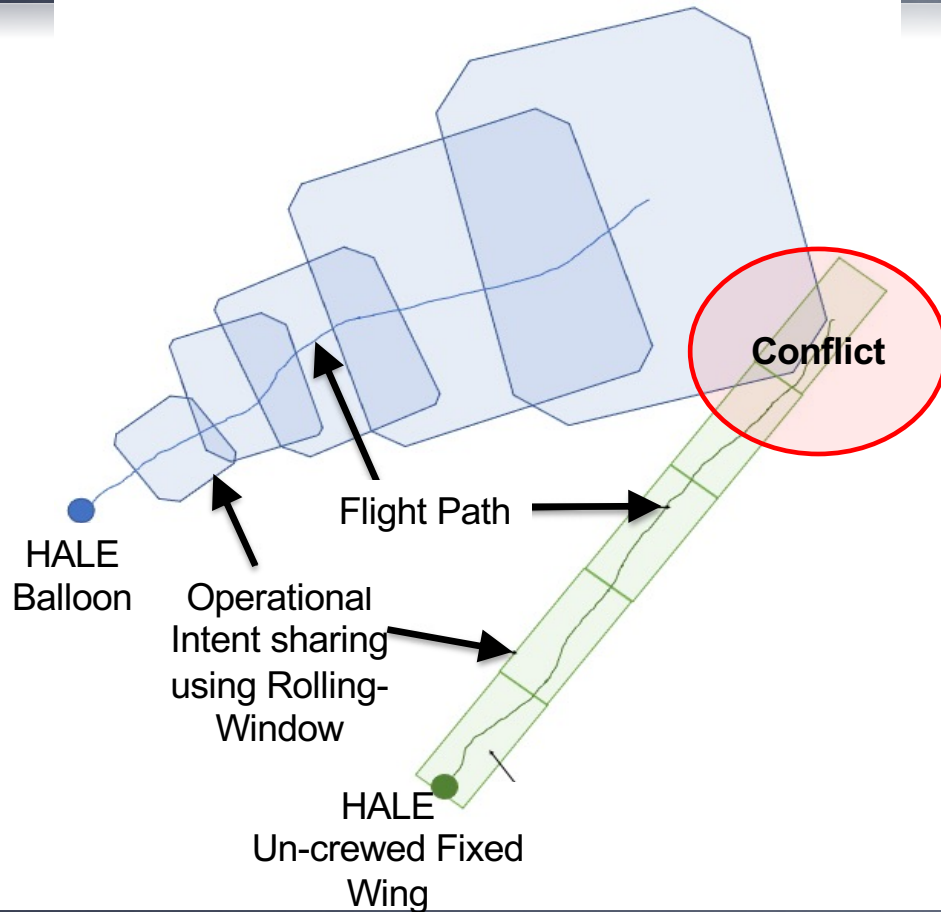


Simplified xTM System Architecture for Upper Class E Traffic Management (ETM)

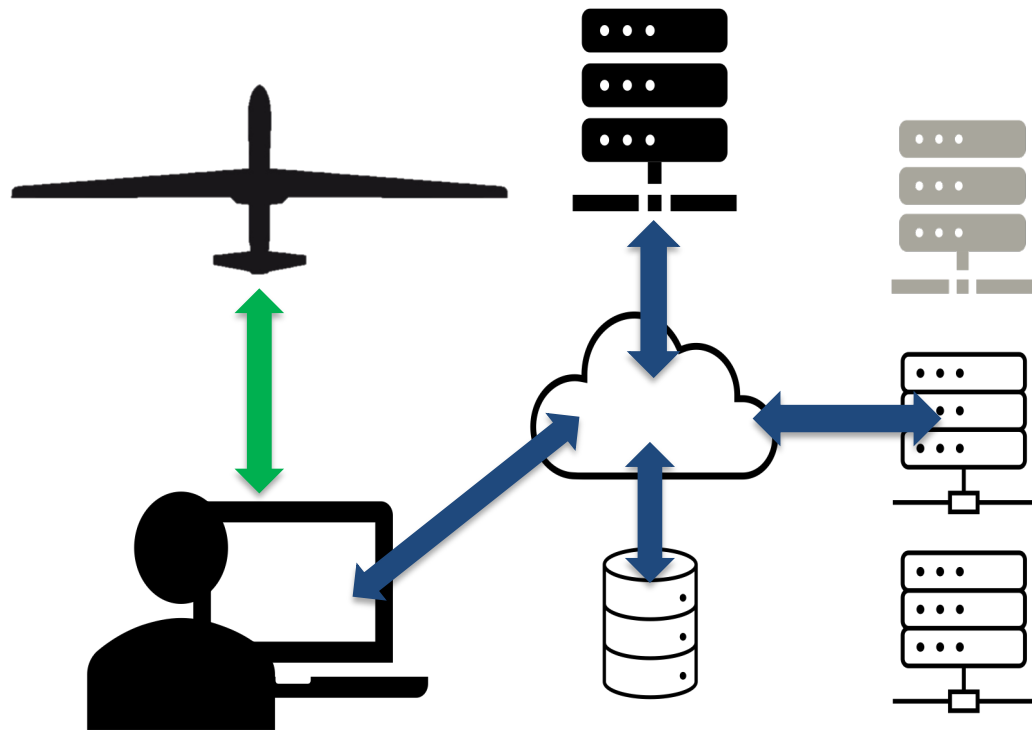


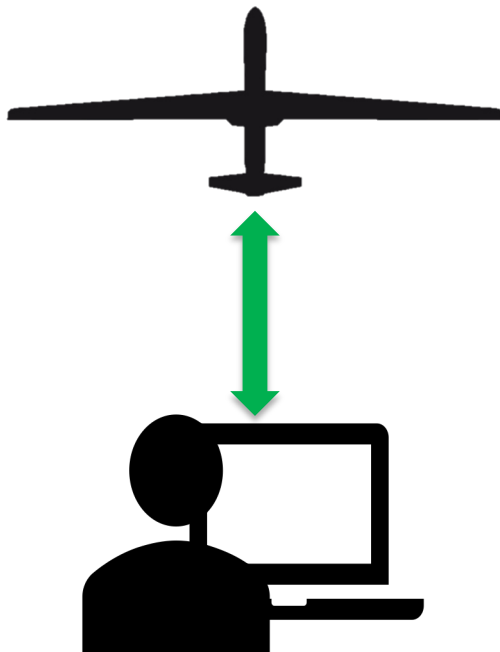
Operation Planning in ETM





When future conflict is identified through ESS, operators are to cooperate for the resolution of the conflict





Two main roles of communications

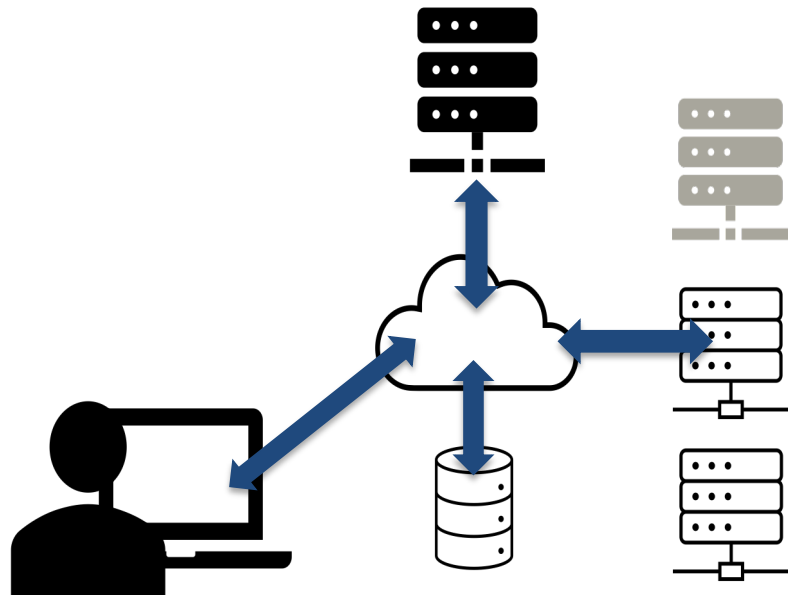
1. Updating aircraft state
2. Commanding aircraft

If communications become

- Not pervasive
- Not predictable
- Not reliable
- Not free
- Operator may lose track of aircraft conformance to the plan
- Aircraft may not receive commands in-time



Role of communications in xTM and associated challenges



Two main roles of communications

1. Coordinating operations
2. Maintaining situational awareness

If communications become

- Not pervasive
- Not predictable
- Not reliable
- Not free
- Operation plans may not be coordinated properly
- Operators may not be informed of changes in the situation in-time



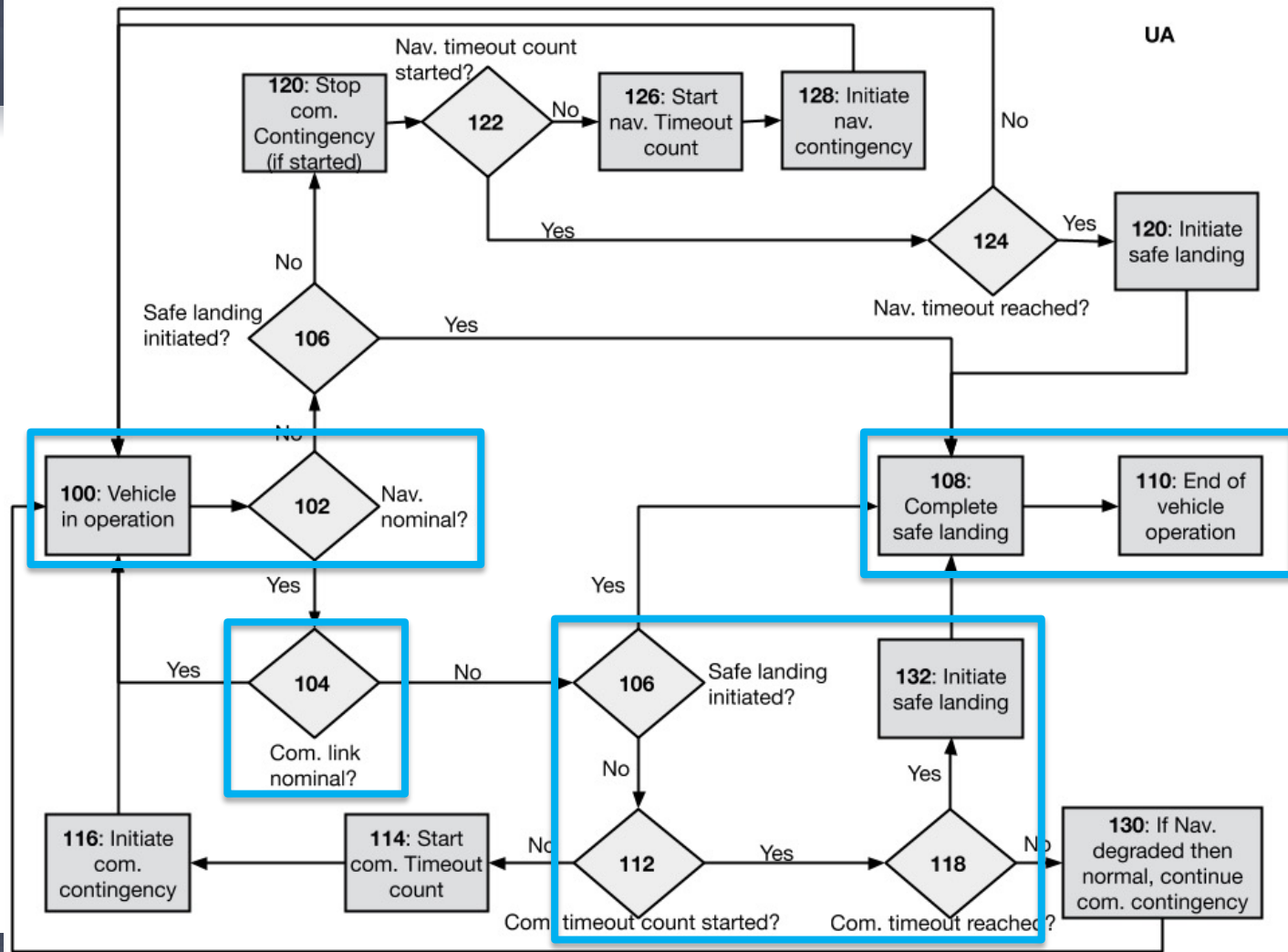
Initial approach for coping with communications challenges in the xTM domain

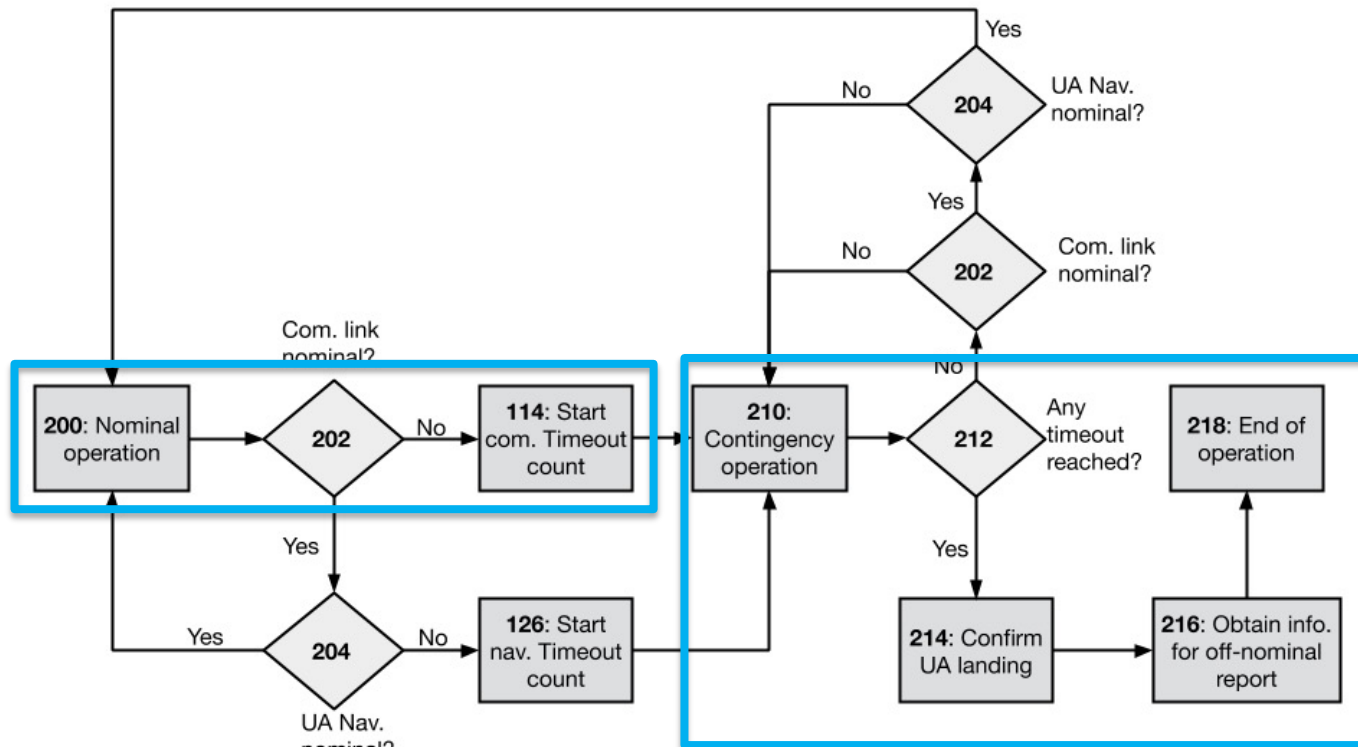
NASA has been advocating the xTM stakeholders to:

- Define nominal communications performance matching their needs and reflecting the operational environment
- Develop preventive measures to minimize the occurrence of off-nominal events
- Prepare mitigation steps to reduce the impact of off-nominal events

To process off-nominal events, the followings are introduced

- Limited time to return to normalcy (timeout)
- Safe landing
- Air-Ground integrated off-nominal event handling







Summary



- xTM is an automated traffic management system for new entrants
- When communications are not pervasive, not predictable, and not reliable it poses challenges to xTM operations
- An initial approach to process communications off-nominal events in the xTM domain has been developed. Suggestions and guidance from multi-agent autonomous systems experts are welcome!



NASA's xTM Publications (examples, not an exhaustive list)

"Define Minimum Safe Operational Volume for Aerial Vehicles in Upper Class E Airspace"	M. Xue and A. K. Ishihara	AIAA Aviation2021, Virtual event	August 2-6, 2021
"Cooperative Upper Class E Airspace: Concept of Operations and Simulation Development for Operational Feasibility Assessment"	H. Yoo, J. Li, J. Homola, and J. Jung	AIAA Aviation2021, Virtual event	August 2-6, 2021
"Identifying Common Use Cases across Extensible Traffic Management (xTM) for Interactions with Air Traffic Controllers"	P. Lee, R. Chartrand, R. Oseguera-Lohr, and C. Brasil, C. Gabriel, and M. Evans	AIAA Scitech 2022, San Diego, CA	January 3-7, 2022
"Intent Modeling and Conflict Probability Calculation for Operations in Upper Class E Airspace"	M. Xue, J. Jung, J. Homola, and H. Yoo	AIAA Scitech 2022, San Diego, CA	January 3-7, 2022
"Overview of NASA's Extensible Traffic Management (xTM) Research"	J. Jung, J. Rios, M. Xue, J. Homola, and P. Lee	AIAA Scitech 2022, San Diego, CA	January 3-7, 2022



NASA's xTM related links



UTM

<https://www.nasa.gov/utm>

https://www.faa.gov/uas/research_development/traffic_management/

<https://nari.arc.nasa.gov/utm2021tim>

ETM

<https://nari.arc.nasa.gov/etm2021workshop>

https://www.faa.gov/uas/advanced_operations/upper_class_etm/

UAM/AAM TM

<https://www.nasa.gov/aam>

https://www.faa.gov/uas/advanced_operations/urban_air_mobility/